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Behavioral risk factors for obesity during health transition in Vanuatu, South Pacific

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Abstract

The South Pacific archipelago of Vanuatu, like many developing countries, is currently experiencing a shift in disease burdens from infectious to chronic diseases with economic development. A rapid increase in obesity prevalence represents one component of this “health transition.” We sought to identify behaviors associated with measures of obesity in Vanuatu. We surveyed 534 adults from three islands varying in level of economic development. We measured height; weight; waist and hip circumferences; triceps, subscapular and suprailiac skinfolds; and percent body fat (%BF) by bioelectrical impedance. We assessed diet through 24-hour dietary recall and physical activity patterns using a survey. We calculated prevalence of obesity and central obesity based on multiple indicators (body mass index, %BF, waist circumference, and waist-to-height ratio), and analyzed differences among islands and associations with behavioral patterns. Obesity prevalence was lowest among rural and highest among suburban participants. Prevalence of central obesity was particularly high among women (up to 73.9%), even in rural areas (ranging from 14.7% to 41.2% depending on the measure used). Heavier reliance on animal protein and incorporation of Western foods in the diet – specifically, tinned fish and instant

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Disclosure

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noodles – was significantly associated with increased obesity risk. Even in rural areas where diets and lifestyles remain largely traditional, modest incorporation of Western foods in the diet can contribute to increased risk of obesity. Early prevention efforts are thus particularly important during health transition. Where public health resources are limited, education about dietary change could be the best target for prevention.

Introduction

The burden of obesity has increased rapidly in developing countries in recent decades, with prevalence in many countries as high as or even exceeding that of developed countries (1). This is a component of health transition, which incorporates the shift in disease burden from predominantly infectious to non-communicable diseases (NCDs), increasing prevalence of sociobehavioral illnesses such as alcoholism, and changing health focus and technologies (2). Behavioral changes occurring with economic development contribute to this increase in NCDs: diets begin to include more packaged, processed, and Western foods (nutrition transition) (3, 4) and physical activity levels decline as participation in sedentary wage labor increases (physical activity transition) (5). Faced with the continued threat of infectious diseases and undernutrition, the already-strained health care systems of developing countries lack the money, personnel, and infrastructure to adequately treat obesity and the costly chronic diseases with which it is associated (1, 6). Highlighting relationships among behavioral patterns and obesity risk might allow health officials to focus early prevention programs on the most important (and cost effective) risk factors, before chronic disease rates reach overwhelming levels.

Vanuatu is a South Pacific archipelago with an estimated 255,737 residents in early 2012, mostly (~98%) Melanesian “ni-Vanuatu” (7). Like many countries in the Asia-Pacific region (8–10), Vanuatu is experiencing the combined burden of infectious and chronic diseases characteristic of early phases of health transition. Level of economic development varies among the archipelago’s 68 inhabited islands. Residents of urban areas work largely in wage labor, and supermarkets stock a huge array of Western foods. However, most of the population (~76%) lives in rural areas (7), where subsistence horticulture predominates and diets include largely traditional foods accompanied to varying degrees by Western imports (11, 12). The gradient of economic development among islands, coupled with relatively similar subsistence and dietary patterns within islands and relatively less genetic diversity than in many larger countries, make Vanuatu a good natural experimental model (13) of health transition.

We assessed adult body composition and behavioral patterns including diet, physical activity, and substance use on three islands varying in level of economic development. We compared anthropometric indices and obesity prevalence among islands, and analyzed relationships among these measures and behavioral patterns. These studies might highlight some behaviors that, if targeted early, could help the people of Vanuatu avoid the huge burden of obesity so common around the globe, and might guide studies in other transitional areas.

Methods and Procedures

Fieldwork was completed in June and July 2007 by researchers from Binghamton University in collaboration with a malariometric survey team from Karolinska Institutet, the Vanuatu Ministry of Health, and the Vanuatu National Cultural Council.

Sample

We sampled adults (≥18 years) on three islands varying in degree of economic development (12). The island of Ambae is characterized by small rural villages where subsistence horticulture predominates. Aneityum is also rural, but with a thriving tourism industry, especially since malaria was eradicated from the island in 1991 (14). Finally, Efate is home of the urban capital, Port Vila. Our sample was in a nearby suburb of Port Vila, where wage labor is common but many residents also maintain traditional gardens and some small livestock. The convenience sample included 534 adults: 51 men and 68 women in Ambae, 162 men and 161 women in Aneityum, and 69 men and 23 women in Efate. Mean age did not differ among islands for men (40.1 years in Ambae, 37.1 in Aneityum, 37.3 in Efate, p=0.485) or women (32.9 in Ambae, 35.9 in Aneityum, 40.4 in Efate, p=0.081). Similarly, distribution of participants into 10-year age cohorts did not differ among islands for men (chi-square 5.429, p=0.861) or women (chi-square 9.928, p=0.447), and was similar between the sample and the national population in 2009 (7) for both men (chi-square 6.617, p=0.251) and women (chi-square 7.001, p=0.221).

Field Methods

We used a survey to assess variables potentially associated with chronic disease risk, described in detail elsewhere (12). Participants answered questions about ancestry; family history of hypertension, cardiovascular disease, and obesity; occupation; and subsistence-related activities. We used 24-hour dietary recall to provide data on dietary patterns. We also assessed frequency of sports and sedentary recreation (hours spent watching TV or video and listening to radio). Finally, we assessed frequency of substance use, including alcohol, tobacco, and kava, a traditional drink made from the root of *Piper methysticum* with sedative effects.

We collected anthropometric measurements following standard guidelines (15). Standing height without shoes was measured to the nearest 0.1 cm using a Seca 214 stadiometer (Seca, Germany). Weight and percent body fat (%BF) through bioelectrical impedance were measured using a Tanita TBF-521 digital scale (Arlington Heights, IL). Participants wore light (tropical weather) clothing. Percent BF was calculated following Tanita's equations for men and women. Weight and height were used to calculate body mass index (BMI, kg/m^2). Triceps, subscapular, and suprailiac skinfolds were each measured in mm three times with Lange skinfold calipers (Cambridge, MD). The mean of the three measurements was calculated, and the means summed to provide sum of skinfolds (SSF). Waist circumference (WC) was measured two centimeters above the naval, and hip circumference (HC) at the maximum circumference, to the nearest 0.1 cm. Waist-to-hip ratio (WHR) was calculated by dividing WC by HC, and waist-to-height ratio (WHTR) was calculated by dividing WC by height. WC and HC measurements were taken over the clothing for most women, who wore light dresses.

We analyzed prevalence of overweight and obesity using cutoffs for BMI (≥25 kg/m^2 and ≥30 kg/m^2) (16) as well as %BF (>25% for men, >35% for women) (17). We analyzed prevalence of central obesity using measurements for WC (central obesity Class I, ≥94 cm for men and ≥80 cm for women; central obesity Class II, ≥102 cm for men and ≥88 cm for women) (17, 18), as well as cutoffs for WHTR (>0.5) (19).

Statistical Methods

One-way and univariate ANOVA were used to analyze differences in means of anthropometric indices among islands. Categorical variables were analyzed using chi-square test for independence. We used figures from the 2009 Vanuatu census (7) to calculate directly age-standardized prevalence rates of obesity for each island.

Linear and logistic regression were used to analyze associations among survey variables and anthropometric indices. Variables with p<0.05 were allowed to enter stepwise. Demographic variables (sex, age, island of residence, years of education) were allowed to enter in block 1; medical history variables (having relatives with hypertension or cardiovascular disease, having relatives with overweight or obesity; No=0, Yes=1) in block 2; consumption of common foods identified from dietary recall (12) (bread/biscuits, rice, noodles, traditional starch/vegetables, fresh fish, tinned fish, fresh meat, tinned meat, multiple fish/meat dishes; No=0, Yes=1) in block 3; occupation (gardening and housekeeping as primary work, sedentary occupation; No=0, Yes=1) in block 4; recreational activity (frequency of sports participation; Seldom/Never=0, Yearly=1, Monthly=2, Weekly=3, Daily=4; hours of TV/radio/video per day) in block 5; and substance use (cigarettes per day, alcohol frequency, kava frequency; Seldom/Never=0, Yearly=1, Monthly=2, Weekly=3, Daily=4) in block 6. Variations in the models, including allowing activity variables to enter before dietary variables, and splitting analyses by sex, were also tested. Analyses were conducted with SPSS 20.0 (IBM SPSS Statistics, NY).

Results

Anthropometric Indices

One-way ANOVA indicated significant among-island differences in mean BMI (p=0.004), %BF (p=0.019), and WC (p=0.002) among men and in all anthropometric indices among women (BMI p=0.001; %BF p<0.001; WC p<0.001; WHR p=0.011; WHTR p<0.001; SSF p=0.002). Among-island differences persisted in univariate analyses controlling for age (Table 1). Among men, means of most anthropometric indices were lowest in Ambae (rural), intermediate in Aneityum (rural with tourism), and highest in Efate (suburban), following a gradient of economic development, with the exception of SSF. The same pattern was observed among women for BMI, %BF, WC, WHTR, and SSF. In contrast, WHR was lowest in Ambae, intermediate in Efate, and highest in Aneityum.

Patterns of obesity prevalence among islands (Table 2) showed similar trends as anthropometric indices: risk increased with level of economic development. Significant among-island differences were observed for obesity prevalence defined by %BF for women ($p<0.001$), central obesity defined by WC (Class I and II) for men ($p=0.013$) and women ($p=0.004$), and central obesity Class II for women ($p=0.001$). Age-standardized prevalence rates were in accordance with sample prevalence with the exception of age-standardized prevalence of obesity based on %BF (36.2%) and central obesity Class II (42.1%) among women in Efate, which were notably lower than the sample prevalence (47.8% and 52.2%, respectively). This is likely owing to the observation of few cases among younger cohorts (18–24 and 25–34 year-olds) based on this measure and the heavy weight of these cohorts in age standardization.

Factors Associated with Body Composition

Linear regression highlighted several factors associated with body composition (BMI, %BF, WC, WHR, WHTR, and SSF). Island of residence was positively associated with all measures of body composition, indicating increases in anthropometric indices with level of economic development from Ambae to Aneityum to Efate. Sex was positively associated with BMI, %BF, WHTR, and SSF, indicating greater values among women. Finally, having overweight or obese relatives was positively associated with BMI, WC, WHTR, and SSF. Controlling for these, several common behavioral variables were associated with body composition, including consuming tinned fish (positively associated, accounting for 1.5%–2.7% of variance) and multiple fish/meat dishes (positively associated, 0.7%–2.2% of variance), gardening and housekeeping as the primary occupation (negatively associated, 1.3%–2.4% of variance), and hours of TV/radio/video per week (negatively associated, 0.9%–1.3% of variance). We also observed negative associations between consuming fresh meat in dietary recall and WC (0.9% of variance) and SSF (0.6% of variance), and frequency of kava intake and BMI (0.8% of variance). The models explained from 21.4% to 46.8% of variance in anthropometric indices, with behavioral variables accounting for 2.5% to 6.4% of variance. Table 3 presents the final linear regression models for BMI, %BF, WC, and SSF. WHTR and WHR are excluded because they revealed similar patterns as WC alone.

Analyses split by sex and analyses among the entire sample in which physical activity variables were allowed to enter before dietary variables revealed the same patterns of risk and protective factors. The most notable difference was the inclusion of frequency of sports participation (1.7% of variance, $B=-0.007$) and alcohol intake (1.4% of variance, $B=0.008$) in equations for WHR for men only in analyses split by sex.

Risk Factors for Obesity

The common behavioral variables observed in linear regression models for body composition were also observed in logistic regression models for overweight, obesity, and central obesity. The percentage of participants correctly classified by these models was 69.2% for overweight/obesity defined by BMI, 90.8% for obesity defined by BMI, 81.9% for obesity defined by %BF, 76.6% for central obesity Class I, 88.7% for central obesity Class II, and 73.0% for central obesity defined by WHTR. Table 4 presents the best three models (obesity by BMI, obesity by %BF, and central obesity Class II). Behavioral variables present in at least two of these models are summarized here. Risk factors included consuming tinned fish (ORs from 1.92–2.91) and consuming multiple fish/meat dishes (ORs from 2.10–4.85) in 24-hour dietary recall. Protective factors included hours of TV/video/ radio per day (ORs from 0.70–0.80) and gardening and housekeeping as the primary occupation (ORs from 0.28–0.49).

Analyses split by sex and analyses among the entire sample in which physical activity variables were allowed to enter before dietary variables revealed the same patterns of risk and protective factors. The most notable difference was the inclusion of noodles in two equations for men only in analyses split by sex [OR=11.58 (p=0.032) and 19.48 (p=0.002)].

Discussion

Vanuatu, like many developing countries (6), is experiencing a rapid increase in obesity with modernization. This is most evident in more economically developed regions such as suburban Efate. However, obesity represents an increasing concern for rural residents, especially in areas experiencing rapid cultural change such as Aneityum (rural with tourism). Prevalence of central obesity is particularly high among women, even in rural Ambae, where we might expect that largely traditional diets and lifestyles would result in low prevalence but where more than one-third of women have central obesity. These figures highlight the importance of assessing multiple indices of obesity in the population (20). Estimates based on total body fat or abdominal fat could indicate increased risk in rural areas that might not be evident in analyses of BMI alone.

Our results suggest that increased animal protein intake is one behavioral contributor to increased obesity risk. The pattern of increased meat intake with economic development has been observed around the globe (4). This often includes a heavier reliance on processed foods, such as tinned fish in our survey, which contributes independently to measures of obesity. We might expect similar risks associated with tinned meat intake, but tinned meat is more expensive and was thus consumed by relatively few participants in our survey (12).

Both the nutrient content and the preparation methods of tinned fish likely contribute to its association with obesity. Tinned fish canned in oil or sauce has higher fat content than most types of fresh fish (21). Furthermore, based on our observations, tinned fish and meat are often served with instant noodles and rice, whereas fresh fish and meat more often accompany dishes made with traditional root crops and vegetables, which are less calorie-dense by comparison. A heavy reliance on tinned fish in urban areas was noted during the first known nutrition survey conducted in Vanuatu in 1951 (22), and has been observed in many areas of the Pacific (23–25).

Our findings are similar to those of the Vanuatu Ministry of Health 1998 NCD survey, which highlighted associations among obesity and daily consumption of nontraditional fat sources (OR=2.19), including oil, margarine/butter, milk, fresh meat, poultry, tinned meat, and tinned fish (11). However, our analyses suggest that tinned fish might contribute more to the risk of nontraditional fats compared to fresh meat (including poultry). In fact, including fresh meat in the nontraditional fats category might actually weaken the observed association, since this emerged as a protective factor in linear regression models, perhaps because fresh meat displaces other less healthy options in the diet. While fresh fish remains a major part of the diet in Vanuatu, it is not available in all areas and only seasonally in others. In this case, fresh meat might be a better dietary option than tinned fish.

Refined carbohydrates might also contribute to increased obesity risk. Packaged “2-minute” noodles are popular in Vanuatu and were associated with increased risk of obesity based on %BF among the whole sample, and with overweight/obesity based on BMI and obesity based on %BF among men. Nutrition education is not widespread in Vanuatu, so it is not commonly known how energy-dense and nutrient-poor these products are. They are chosen largely for their convenience (24). Malcolm noted in 1952 that most people had little knowledge of the nutritional value of different classes of foods and recommended prioritizing nutrition education (22). Those recommendations remain equally relevant today (26).

Associations with physical activity variables were less robust in our analyses. Whereas we expected that spending more hours in sedentary recreation would be associated with increased risk, this actually emerged as a protective factor. We suspected that this might reflect higher levels of education among participants who spent more time in these forms of sedentary recreation: years of education was positively correlated with hours of TV/video/radio per week among both men and women [correlation 0.227 ($p<0.001$) and 0.181 ($p=0.007$), respectively], and these correlations remained significant even when controlling for age. However, years of education was not a significant predictor in any of our linear or logistic analyses. Nevertheless, participants who spend more time listening to TV and radio might receive more informal health education in the form of public health messages or popular opinions.

The 1998 Vanuatu NCD survey (11) included a physical activity score based on frequency (0=Never, 1=Weekly, 2=Daily) of gardening, sports, and walking to work/garden, with a minimum score of 0 and a maximum score of 6. The only statistically significant differences were between individuals with light and moderate activity levels combined (score 0–4) compared to those with heavy activity (score 5–6) (OR=1.59). We calculated similar composite measures of physical activity, but none were reliably correlated with anthropometric indices or obesity risk.

Notably, the effects of physical activity and sedentary recreation on BMI appear to be most evident among individuals classified as obese (27), and so might not be evident in our sample. Although obesity represents a growing concern on all the islands sampled, more than 60% of our participants had a BMI within the normal range and, depending on the criteria used, as few as 10% were classified as obese. Furthermore, physical activity levels were high among all participants in our sample, even those who spent the most time in sedentary recreation (12). For example, most people walked for their daily errands and activities, with only 8.5% of men and 1.6% of women reporting taking a vehicle to work or gardens. Only 3.9% of men and 1.2% of women had jobs requiring little physical activity, and all but one participant maintained at least one (but usually multiple) traditional gardens, which was a protective factor in our analyses. Tending traditional gardens is labor intensive, and since gardens might be located up to few hours away from the household by foot, simply getting to the garden requires extended periods of physical activity. Finally, physically active recreation was popular on all islands. For example, 48.7% of men and 39.9% of women played sports on at least a weekly basis. In contrast, fewer participants spent extended periods of time in sedentary recreation. Daily hours of TV/radio/video averaged 1.69 hours for men and 0.85 hours for women, and only 27.2% of men and 11.7% of women watched more than 2 hours of TV per day. Sedentary behaviors and physical activity might each contribute uniquely to health outcomes (28), and more analyses are thus necessary to identify the potential effects of sedentary behavior, and of subtle changes in physical activity levels, in this and similar highly active populations.

While our models for obesity correctly classify up to 90% of participants, other major contributors to obesity remain unaccounted for in our sample. Early growth patterns and genetic profile likely have a major impact on obesity risk in Vanuatu. For example, poor intrauterine growth followed by rapid catch-up growth contributes to increased risk of obesity later in life, and is a particularly important risk factor in developing countries (29, 30). Our analyses among adolescents showed higher than expected WHTR and central obesity prevalence among girls in Aneityum, and some evidence suggests that stunting in infancy might represent a contributing factor (31). Furthermore, a number of genetic risk factors for chronic diseases have been identified in Pacific populations (32), and this could account for much of the unexplained variance in anthropometric indices and obesity risk on all islands.

In areas experiencing rapid cultural change, obesity prevalence can increase in only a short period of time. Follow-up surveys conducted by our group in 2011 suggest that prevalence of obesity (defined by BMI) has increased since 2007 among both men and women in Efate (33). This points to the importance of frequently monitoring population health and implementing prevention efforts early during transition, including in rural areas that might otherwise be overlooked due to relatively lower prevalence of obesity compared to urban areas.

In conclusion, our analyses suggest that relatively modest changes in behavior, diet in particular, can contribute markedly to increasing obesity prevalence during health transition. Despite the maintenance of traditional gardening among most residents, high levels of physical activity, and continued reliance on traditional foods, the incorporation of more animal protein and refined carbohydrates is large enough to contribute to increased risk of obesity in the archipelago. In light of the rapidity of weight gain observed during modernization, targeting rural areas where increasing tourism or other environmental factors lead to even modest changes in lifestyle represents an important public health focus. Where public health resources are limited, prioritizing messages about the risks of packaged and processed foods such as instant noodles, and heavy reliance on animal protein – especially more processed forms – could have a positive impact on population health. Early implementation of prevention measures coupled with continued monitoring of multiple measures of obesity could help countries in the early stages of health transition avoid the costly health burdens so prevalent in developed countries today.

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Table 1

Anthropometric indices by island: Estimated marginal means controlled for age

Men	Ambae	Aneityum	Efate	p-value
BMI	22.9	24.7	24.9	0.001
% Body Fat	15.7	18.1	19.0	0.003
Waist Circumference (cm)	76.8	81.3	84.5	<0.001
Waist to Hip Ratio	0.85	0.87	0.88	0.015
Waist to Height Ratio	0.47	0.49	0.50	0.013
Sum of Skinfolds (mm)	47.4	47.1	49.4	0.660
Women				
BMI	23.4	24.9	26.9	0.002
% Body Fat	26.0	29.2	34.4	<0.001
Waist Circumference (cm)	77.1	81.5	87.2	<0.001
Waist to Hip Ratio	0.84	0.87	0.85	0.033
Waist to Height Ratio	0.50	0.52	0.55	0.002
Sum of Skinfolds (mm)	63.0	68.5	79.4	0.005

Table 2

Prevalence of obesity and central obesity (age-standardized prevalence in parentheses) based on multiple indicators.

Men		**Ambae**	**Aneityum**	**Efate**	**p-value**
Obesity	BMI	2.0	6.2	13.2	0.222
	(Age-standardized)	(1.5)	(5.5)	(13.5)	
	%BF	7.8	13.0	22.1	0.070
	(Age-standardized)	(6.8)	(11.7)	(22.6)	
Central Obesity	WC, Class I & II	3.9	11.7	21.7	0.013
	(Age-standardized)	(3.1)	(10.5)	(22.5)	
	WC, Class II only	2.0	6.8	8.7	0.312
	(Age-standardized)	(1.5)	(6.3)	(8.7)	
	WHTR	23.5	35.2	37.7	0.222
	(Age-standardized)	(19.1)	(31.5)	(36.0)	
Women					
Obesity	BMI	7.4	11.8	21.7	0.171
	(Age-standardized)	(6.1)	(11.4)	(17.8)	
	%BF	10.3	19.9	47.8	<0.001
	(Age-standardized)	(8.3)	(20.2)	(36.2)	
Central Obesity	WC, Class I & II	35.3	50.3	73.9	0.004
	(Age-standardized)	(34.2)	(49.1)	(70.9)	
	WC, Class II only	14.7	24.8	52.2	0.001
	(Age-standardized)	(13.9)	(24.0)	(42.1)	
	WHTR	41.2	55.3	65.2	0.064
	(Age-standardized)	(39.8)	(53.4)	(62.7)	

Table 3

Associations among behavioral variables and anthropometric indices based on linear regression analyses

	Values in final model		Values after entry of each variable			
Predictor Variables	**B**	**B p-value**	**R^2**	**ΔR^2**	**F**	**Sig ΔF**
BMI						
(Constant)	19.280	<0.001				
Age (years)	0.070	<0.001	0.075	0.075	33.323	<0.001
Island [a]	1.639	<0.001	0.117	0.042	19.725	<0.001
Sex [b]	0.532	0.182	0.126	0.009	4.291	0.039
Relatives OW/Obese [c]	1.240	0.001	0.152	0.026	12.758	<0.001
Tinned Fish [d]	1.483	0.006	0.169	0.017	8.132	0.005
Gardening/Housekeeping [e]	−1.481	0.001	0.193	0.024	11.998	0.001
Hours TV/Radio/Video	−0.283	0.008	0.205	0.013	6.491	0.011
Kava Frequency [f]	−0.259	0.038	0.214	0.008	4.325	0.038
% Body Fat						
(Constant)	−1.340	0.469				
Sex [b]	11.617	<0.001	0.361	0.361	232.857	<0.001
Island [a]	3.185	<0.001	0.401	0.040	27.685	<0.001
Age (years)	0.092	<0.001	0.428	0.027	19.257	<0.001
Tinned Fish [d]	2.985	0.002	0.443	0.015	11.114	0.001
Gardening/Housekeeping [e]	−2.450	0.002	0.457	0.014	10.634	0.001
Hours TV/Radio/Video	−0.552	0.004	0.468	0.011	8.301	0.004
Waist Circumference						
(Constant)	62.132	<0.001				
Age (years)	0.358	<0.001	0.225	0.225	120.046	<0.001
Island [a]	4.053	<0.001	0.293	0.068	39.574	<0.001
Relatives OW/Obese [c]	2.801	0.003	0.307	0.013	7.949	0.005
Multiple Fish/Meat Dishes [d]	5.968	<0.001	0.328	0.022	13.283	<0.001

Predictor Variables	Values in final model		Values after entry of each variable			
	B	**B p-value**	**R^2**	**ΔR^2**	**F**	**Sig ΔF**
Fresh Meat [d]	−2.076	0.085	0.337	0.009	5.420	0.020
Gardening/Housekeeping [e]	−3.086	0.004	0.350	0.013	8.164	0.004
Hours TV/Radio/Video	−0.658	0.017	0.359	0.009	5.726	0.017
Sum of Skinfolds						
(Constant)	4.765	0.369				
Sex [b]	23.097	<0.001	0.180	0.180	89.052	<0.001
Age (years)	0.559	<0.001	0.304	0.123	71.505	<0.001
Island [a]	1.431	0.346	0.312	0.009	5.156	0.024
Relatives OW/Obese [c]	4.584	0.014	0.323	0.010	6.116	0.014
Tinned Fish [d]	8.462	0.003	0.350	0.027	16.623	<0.001
Multiple Fish/Meat Dishes [d]	7.584	0.010	0.357	0.007	4.523	0.034
Fresh Meat [d]	−4.261	0.081	0.363	0.006	3.922	0.048
Gardening/Housekeeping [e]	−8.684	<0.001	0.387	0.024	15.434	<0.001

a) 1=Ambae, 2=Aneityum, 3=Efate

b) 1=Male, 2=Female

c) 0=No, 1=Yes

d) Consumed in 24-hour dietary recall, 0=No, 1=Yes

e) Primary occupation, 0=No, 1=Yes

f) 0=Seldom/Never, 1=Yearly, 2=Monthly, 3=Weekly, 4=Daily

Table 4

Logistic regression models for obesity and central obesity

Predictor variable	Odds Ratio	95% CI	p-value
Obesity by BMI (90.8% of participants correctly classified)			
Sex [a]	3.42	1.55–7.55	0.002
Age	1.06	1.03–1.08	<0.001
Island (Reference – Ambae)			0.248
Island (Aneityum)	1.55	0.46–5.29	0.481
Island (Efate)	2.93	0.72–11.86	0.132
Relatives Overweight [b]	3.64	1.70–7.78	0.001
Tinned Fish [c]	2.91	1.18–7.16	0.020
Multiple Fish/Meat [c]	3.24	1.32–7.95	0.010
Gardening/Housekeeping [d]	0.28	0.13–0.63	0.002
Constant	0.00		<0.001
Obesity by %BF (81.9% of participants correctly classified)			
Sex [a]	1.90	1.07–3.39	0.030
Age	1.03	1.01–1.05	<0.001
Island (Reference – Ambae)			0.003
Island (Aneityum)	2.14	0.91–5.00	0.080
Island (Efate)	6.58	2.16–20.04	0.001
Tinned Fish [c]	1.92	0.89–4.17	0.098
Multiple Fish/Meat [c]	2.10	1.03–4.31	0.042
Noodles [c]	3.75	1.15–12.27	0.029
Gardening/Housekeeping [d]	0.49	0.27–0.90	0.022
Hours TV/Radio	0.80	0.65–0.98	0.033
Constant	0.02		<0.001
Central Obesity II (WC) (88.7% of participants correctly classified)			
Sex [a]	15.25	6.50–35.78	<0.001
Age	1.08	1.05–1.11	<0.001
Island (Reference – Ambae)			0.015
Island (Aneityum)	2.70	1.04–7.00	0.041
Island (Efate)	7.10	1.86–27.10	0.004
Multiple Fish/Meat [c]	4.85	1.99–11.81	0.001
Gardening/Housekeeping [d]	0.45	0.21–0.98	0.045
Hours TV/Radio	0.70	0.52–0.95	0.023
Constant	0.00		<0.001

[a)] 1=Male, 2=Female

[b)] 0=No, 1=Yes

[c)]Consumed in 24-hour dietary recall, 0=No, 1=Yes

[d)]Primary occupation, 0=No, 1=Yes

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